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TECHNICAL NOTE

Automatic device for cross-circulation experiments or prolonged infusions in rats

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Several experiments using cross-circulation between rats have appeared in the literature in recent years. Pearce et al [1] have reported on a technique with which two rats can be cross-circulated when placed on opposite pans of a trip balance, the blood flow of the two animals being adjusted with clamps to keep their weights constant. This ingenious system requires an attendant to make such adjustments, however, a considerable disadvantage when experiments are to last several hours or days. Here, we report on a simple modification that permits the performance of cross-circulation experiments over protracted periods of time without the need for constant monitoring.

Animals are anesthetized for insertion of a PE-50 catheter in the femoral or carotid artery and placement of a return catheter in a suitable vein. These lines are filled with a dilute heparin solution and are allowed to fill with blood just before cross-circulation is begun. Heparin, 100 U USP, is given s.c. to each rat, and bladder catheters are introduced if needed in the experimental protocol. The physical arrangement of the system is shown in Fig. 1. Studies may be performed with the animals either anesthetized or awake and loosely restrained in a plastic (Lucite™) holder, which rests on a 3-inch-high cradle to keep them from disturbing the balance by their movement. The cannulae and, unless the protocol dictates otherwise, preweighed urine containers of the animals are attached to the pan of the scale (Ohaus 1550 SD). When urine volumes of the two animals are very different, or in dealing with a single rat (see below), one may opt to drain the urine into a container away from the balance. The arterial line of each rat passes through a roller pump and thence to a vein of the other rat. One pump, receiving arterial blood from the animal on the right-hand (facing) balance pan, runs continuously at a predetermined rate. We use a rate of 1 ml/min. The other pump (Holter 907, Medical Specialties Co.) is actuated by a photoelectric cell (GE H13B1) with self-contained light-source set in the base of the left-hand side of the balance. When a gain in weight displaces that balance pan downward, the photoelectric cell activates a relay controlling the Holter pump whose batteries are removed so that it runs only when directed by the relay. Breaking the light beam normally activates this slave pump; the circuit provides the capacity for pump activation with opening of the light path when desired (see below). A schematic circuit diagram of the photo cell attachment and relay system is shown in Fig. 2. The two infusion pumps need not be the same, and the relay circuit can be modified readily to accommodate the characteristics of any suitable roller pump. The photo-cell-activated pump is set to have a rate somewhat higher than the other so as to cycle on and off at intervals of 5 to 10 sec and, using small-bore catheter tubing, thus minimize the exposure of blood within the tubing to the external environment. With this balance system, a net weight difference of < 0.2 g between the two animals activates the pump, which automatically turns off as the beam returns towards the balance point. The system shows little random hysteresis. Because any weight gain of the recipient rats is matched by an equivalent loss in the donor animal, the blood volume change of either rat due to cross-circulation never exceeds 0.1 g before equalization is begun. The system has been used for cross-circulation experiments lasting for more than 6 hours in non-anesthetized animals without evident hemolysis or

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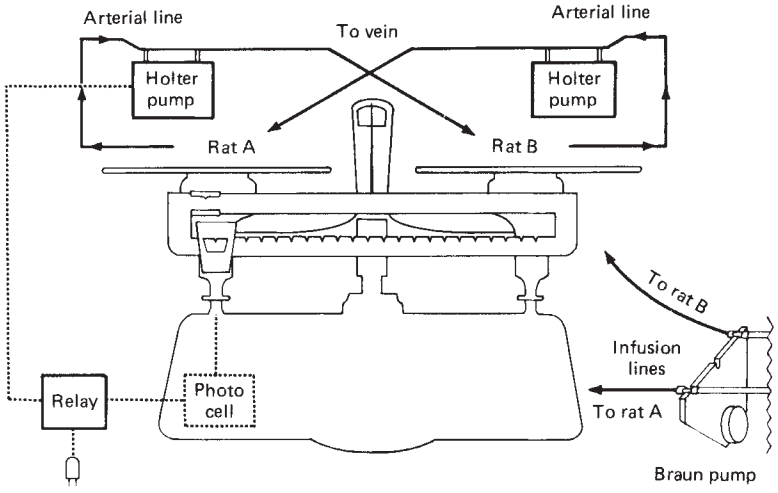

Fig. 1. *Arrangement of apparatus for cross-circulation experiments.*

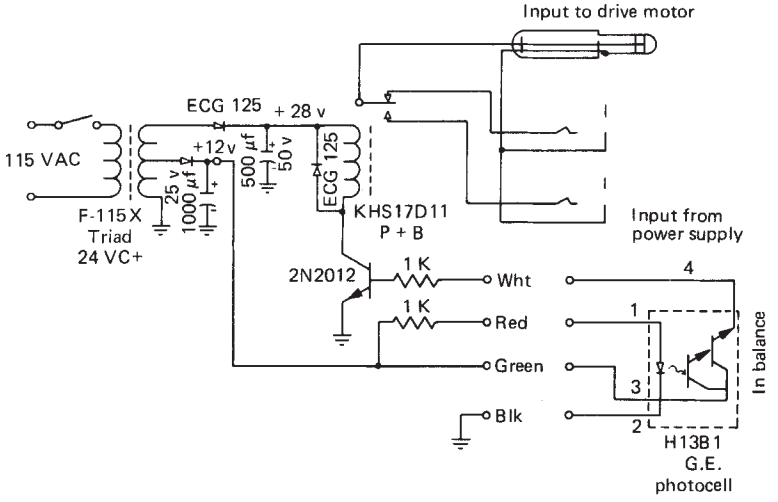

Fig. 2. *Schematic diagram of the photocell-relay system.*

other untoward effects. A Braun pump (Unita 2, Scientific Products Co.) with paired precision ground 5-ml syringes is used to infuse the animals with fluids during the experiment. A thermistor-controlled heating pad placed on each balance pan is recommended for protracted experiments on anesthetized rats.

The same device can be used either with one of a cross-circulated pair of rats removed from the balance, if that is necessary for a given experiment, or for accurate replacement of large volumes of urine and insensible fluid losses by a single rat over many hours. Here, one animal is placed on the relay activating balance pan with its weight accurately matched by a fixed weight and tare bar adjustment. A reversal arrangement on the relay system (Fig. 2) is set to now call for the pump to turn on as the animal's weight falls below baseline and turn off when baseline weight is restored.

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